

**FILE COPY**14212  
MAY 1990

## Voluntary Export Restraints and Resource Allocation in Exporting Countries

Jaime de Melo and L. Alan Winters

---

*This article analyzes the resource implications of voluntary export restraints (VERs) for exporting countries. A simple analytical method is used to demonstrate that, by reducing the marginal revenue of its factors of production, a VER causes an industry in the exporting country to contract, and that the efficiency losses from a VER depend on the ease with which sales can be diverted from the restricted toward the unrestricted markets. The method is applied to test the effects of the U.S. Orderly Marketing Agreement (OMA) for producers of leather footwear in the Republic of Korea during the period 1977-81. We estimate that the marginal revenue product of factors employed in leather footwear declined by as much as 9 percent because of the OMA, an estimate that is corroborated by inspection of time series on output, employment, and wages of the Korean footwear sector. This implies that there was pressure on the Korean footwear industry to contract as a result of the OMA.*

---

Most previous investigators of the effects of voluntary export restraints have been concerned with the welfare costs of such restraints to consumers in importing countries. Examples of previous studies include: estimates of quality adjusted welfare costs of VERs on automobiles (Feenstra 1984; Dinopoulos and Kreinin 1988); the claim that, for commodities with little product differentiation and low start-up costs (for example, footwear and textiles), VERs are ineffective (Baldwin 1982; Bhagwati 1986); and simulations which show that terms of trade effects are likely to reduce substantially the costs of (gains from) VERs to importing (exporting) countries (Tarr 1987; Trela and Whalley 1988). None of these studies—even those which look into the implications of VERs for exporters—contain investigations into the effects of VERs on resource allocation in exporting countries. This article fills the gap.

For the sake of simplicity, we analyze the effects of a VER in two steps. First,

Jaime de Melo is an economist at the World Bank and an associate of the Centre for Economic Policy Research, London. L. Alan Winters is a professor of economics at the University of Birmingham and an associate of the Centre for Economic Policy Research. The authors thank three referees, Wendy Takacs, Paul Brenton, and Taeho Bark, participants at the Centro Interuniversitario di Studi Teorici per la Politica Economica—Centre for Economic Policy Research Conference in Venice, May 1988 and at the European Research Workshop in International Trade in Bergen in July 1989 for helpful comments on an earlier draft. They also thank Maria Ameal and Alexander Pfaff for logistical support.

© 1990 The International Bank for Reconstruction and Development / THE WORLD BANK.

we consider a very-short-run equilibrium in which the size of the exporting industry is fixed. Second, we consider the pressures at this equilibrium for the industry to contract. When the size of the exporting industry is fixed, firms respond to the VER by reallocating sales away from the restricted to some other (unrestricted) export market. Such diversions of exports are assumed to have increasing opportunity costs, which implies that the commodities exported to the two markets are *not* perfect substitutes in production—perhaps because they have different characteristics. Two effects of a VER are distinguished. First, the sales revenues of the exporting firms may rise or fall depending on the elasticities of demand in the restricted and unrestricted markets. Second, there is a misallocation of resources. The VER moves the composition of the export industry's output to a point on the production possibilities curve where its slope is no longer equal to the ratio of the two export prices; this constitutes allocative inefficiency.

In the second step of our analysis, the industry is allowed to shrink in response to the VER. The VER reduces the marginal revenue products of the exporting industry's factors of production, and the industry will contract by an amount dependent on the elasticities of factor supply.

We proceed as follows. The impact of a VER on resource allocation in exporting countries is analyzed in section I. In section II, we present an estimate of the effect of the U.S. Orderly Marketing Agreement (OMA) for nonrubber footwear imports on the Korean leather footwear industry during the period 1977 to 1981. A model is developed to estimate econometrically the slope of the production possibilities curve for the footwear industry. This helps to determine the new point reached on the production possibilities curve as a consequence of the OMA. The difference between the slope of the curve at the new point and the new price ratio is used to estimate the fall in the marginal revenue product for factors employed in the footwear industry. We find that the marginal revenue product may have fallen by as much as 9 percent because of the OMA. (The econometric techniques used in section II are described more fully in appendix A.) In section III we present the results of a simulation exercise. Combining our econometric estimates with alternative assumptions about output demand and factor supply elasticities gives illustrative estimates of the likely welfare effects of the OMA. (The model used to derive the welfare effects is described in appendix B.) Some concluding remarks are made in section IV.

### I. REAL RESOURCE ALLOCATION IMPLICATIONS OF A VER

In this section, we present an analysis of the sales revenue effects and the resource allocation implications for an exporting country entering a VER. We demonstrate under fairly representative conditions that a VER will reduce the marginal revenue product of factor inputs in the affected industry, and hence

reduce the size of the industry. To simplify the exposition, we assume that all output is produced by firms which are identical and perfectly competitive in all product and factor markets. The output is sold in one of two foreign markets. A VER restricts exports to one of these markets while those to the second market remain unrestricted. In addition, while we assume that individual exporting firms are price takers in each export market, the industry as a whole faces downward-sloping demand curves in each market.

The effects of a VER are presented in two steps. Initially it is assumed that industry size is fixed and that there are costs to diverting sales from the restricted toward the unrestricted market. With this assumption, it is a simple matter to analyze the revenue and distortionary implications of the VER. In the second step, we show that a VER will reduce the marginal revenue product of factors employed in the industry, which is likely to lead the industry to contract.

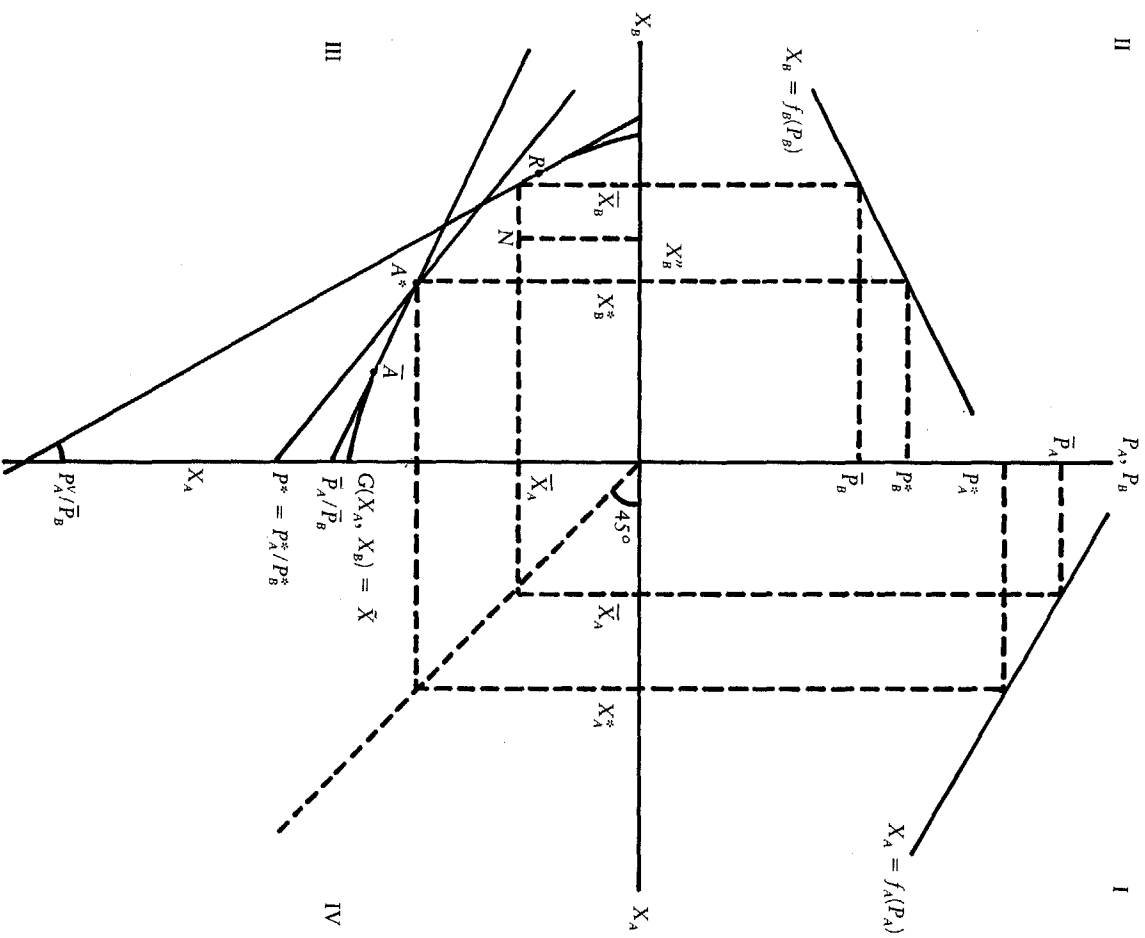
This two-step discussion of the effects of a VER is expositionally convenient and corresponds to the two-stage assumption about firm decisions adopted in the econometric work of section II. We show in appendix B that the independence of (weak separability between) input decisions and sales decisions is not fundamental for the results that are established here.

The assumption that there are increasing marginal costs to the diversion of sales from the restricted toward the unrestricted market may be interpreted as indicating the short-run effects of a VER in an industry characterized by product differentiation. In the short run, where the quantities of factors employed in the industry are fixed, a shift in production between outputs which use factors in different proportions will result in increasing marginal costs. Moreover, if one of the outputs has a specific factor which is in relatively inelastic supply—for example, a particular labor skill—the mere fact that the outputs are differentiated is sufficient to produce an increasing marginal rate of transformation between the two products.

The above assumptions allow us to represent our model diagrammatically. In figure 1, foreign export demands in the restricted (*A*) and unrestricted (*B*) markets are represented in quadrants I and II, respectively, while quadrant III depicts the substitution possibilities facing the industry as it reallocates production between sales for market *A* and those for market *B*. It is obtained by the aggregation of the substitution possibilities facing each exporter. The bowed-out shape of the export transformation curve  $G(X_A, X_B) = \bar{X}$  reflects the assumption of increasing costs of production associated with changing the product mix. Assuming fixed aggregate footwear production  $\bar{X}$ , successive increments in sales to market *B* impose increasing resource costs in terms of larger and larger decreases in export sales to market *A*. Quadrant IV is bisected by the 45° line which translates export sales to *A* from quadrant III to quadrant I.

The unrestricted allocation,  $A^*$ , is represented by the price-quantity pairs  $(P_A^*, X_A^*)$  and  $(P_B^*, X_B^*)$ , where superscript asterisks are used to denote the

Figure 1. *Equilibrium Allocation of Sales*



unrestricted equilibrium. The slope of the export transformation curve is given by

$$MRT_{A,B} = \frac{dX_A}{dX_B} = -\frac{G_B}{G_A} < 0$$

where  $G_i = \partial G / \partial X_i > 0$ ;  $i = A, B$ , indicate positive opportunity costs; and the bowed-out transformation curve reflects the fact that opportunity costs increase with output.<sup>1</sup>

The equilibrium for a competitive industry requires that

$$(1) \quad \frac{G_A^*}{G_B^*} = \frac{P_A^*}{P_B^*}$$

and  $P_i = \theta^* G_i$  where  $\theta^*$  is the marginal cost of producing a unit of  $\bar{X}$ . In figure 1, the equilibrium condition (equation 1) is represented by the tangency of the export transformation curve and the price line,  $P^*$ , at the unrestricted equilibrium,  $A^*$ .

Now impose a VER which restricts exports to A to the level  $\bar{X}_A$ . The restricted allocation is represented by the new price-quantity pairs  $(\bar{P}_A, \bar{X}_A)$  and  $(\bar{P}_B, \bar{X}_B)$  where superscript bars indicate the restricted equilibrium. We decompose the effects of the VER into two parts: a revenue effect, which reflects the way the VER affects the industry's revenue from exporting, and an allocative distortion, which arises as the economy is obliged to produce a non-optimal mix of outputs.

Consider the revenue effect. We have assumed that the industry as a whole comprises a large number of atomistic firms and therefore cannot behave like a discriminating monopolist. The presence of unappropriated monopoly rents means that it is possible that the VER will raise industry revenues. Let  $\epsilon_A$  and  $\epsilon_B$  denote the elasticity of demand in the restricted and unrestricted markets, respectively, and assume  $\epsilon_A, \epsilon_B = 0$ . A departure from the free trade equilibrium will raise revenues if marginal sales revenue is higher in B (unrestricted) than in A (restricted), that is, if  $P_B(1 - 1/\epsilon_B) > P_A(1 - 1/\epsilon_A)$ . Thus if the elasticity of demand is much greater in the unrestricted than in the restricted market, a VER may push sales allocation toward that which would be selected by a discriminating monopolist.<sup>2</sup>

In the case described above, the VER has the same type of effect as an optimum export tax. That exporting governments do not preempt the imposition of an OMA by imposing export taxes of their own volition probably reflects their uncertainty about the long-run elasticities of demand they face, a fear of

1. Increasing marginal costs requires  $G_{AA}, G_{BB} > 0$  and  $G_{AA}G_{BB} - G_{AB}^2 \geq 0$ .

2. While we do not wish to stress the empirical relevance of this possibility, it has been pointed out in previous theoretical discussions of the effects of VERs in non-competitive markets. It is interesting to speculate that the two-tier quota allocation system used in Korea (and elsewhere) implies that greater sales toward non-restricted markets may have the objective of revenue maximization. For further analysis see Bark and de Melo (1988).

retaliation from importing governments, and a fear of reprimand from international organizations. Of course, once importing governments have established OMAs, exporting governments are likely to try to exploit their potential market power through alternative quota allocation schemes. Note that if the exporting industry had initially acted as a discriminating monopolist or faced optimum export taxes, it would already have been maximizing its profits, and hence could only have suffered from the imposition of a VER.

Consider next the allocative distortions caused by the VER. Because we have assumed at this stage that firms maximize revenue for a given level of  $\bar{X}$ , which is equivalent to maximizing profits, the new allocation must lie on the same export transformation curve as the old, and given the exogenous value of  $\bar{X}_A$ , the chosen point will be  $R$ . At this new equilibrium, the equality of relative prices to the marginal rate of transformation no longer holds. The relative price of  $A$  has been forced up by the constraint on sales so that it is tangent to the transformation curve at  $\bar{A}$ , but the marginal rate of transformation ( $MRT_{A,B}$ ) has fallen to  $R$  as the relative output of  $A$  has fallen (see figure 1). Hence

$$\frac{\bar{P}_A}{\bar{P}_B} > \frac{P_A^*}{P_B^*}, \text{ whereas } \frac{\bar{G}_A}{\bar{G}_B} < \frac{G_A^*}{G_B^*}.$$

This violation entails a well-understood distortion cost, which is independent of whether total sales revenues have increased after the imposition of the VER. For producers to choose point  $R$  voluntarily, they would have to face the relative price line  $(P_A^V/\bar{P}_B)$ , which equals the marginal rate of transformation at  $R$ .  $P_A^V$  is known as the virtual price and, as is clear from figure 1, it implies a relative price less than both the unconstrained price  $(P_A^*/P_B^*)$  and the actual price  $(\bar{P}_A/\bar{P}_B)$ .

We now turn to the second step of the discussion and show that the VER will create an incentive for the industry to contract. With production and allocation decisions separable, input mixes (which depend on factor prices) are independent of output mixes (which depend on output prices); hence, given fixed relative factor prices, we can construct a composite factor,  $Z$ , with wage  $W$ . This allows us to characterize production in terms of the aggregate output index as  $\bar{X} = \bar{X}(Z)$  and, assuming constant returns to scale, we can select units such that  $\bar{X} \equiv Z$ . Hence we can assess the effects of a VER on the size of the industry as measured by aggregate input  $Z$ .

In an unrestricted equilibrium, sales are allocated between markets in such a way that the marginal revenue product of a factor devoted to producing goods for market  $A$  equals that of the factor if it were used to produce for market  $B$ . We may write the condition for an unconstrained equilibrium as follows:

$$(2) \quad \frac{dR_A}{dZ} = \frac{dR_B}{dZ} = \frac{dR}{dZ} = W$$

where  $R_A$  is the revenue derived in market  $A$ , and so forth,  $W$  is the cost of factor  $Z$  and, in our earlier notation,

$$\frac{dR_i}{dZ} = \frac{P_i^*}{G_i^*} = \theta^*$$

To assess the effects of the VER on the size of the industry, we need to consider whether the marginal revenue product of  $Z$  is increased or decreased by the VER. This can be done entirely in terms of market  $B$ . Under free trade, the marginal revenue products are equal across markets, whereas under the binding VER, only market  $B$  can accommodate marginal sales. The marginal revenue product in  $B$  falls as more and more sales are switched to  $B$ , but while the VER is binding, the marginal revenue product in  $A$  is zero. Hence marginal product for a given  $Z$  falls. Constrained revenue maximization by the representative firm implies that in the new equilibrium:

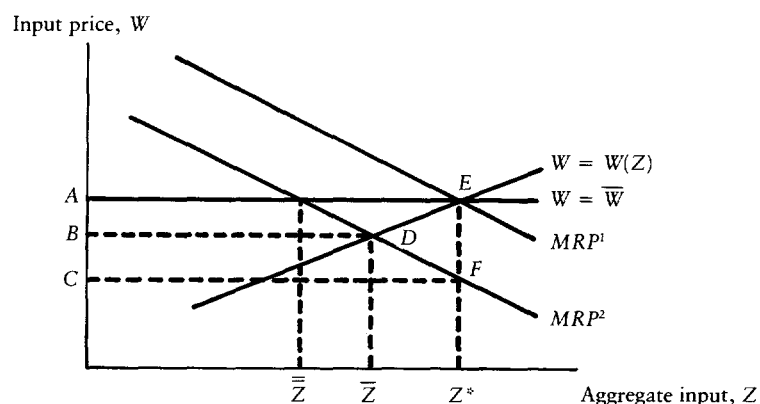
$$(3) \quad \frac{d\bar{R}_B}{dZ} = \frac{\bar{P}_B}{G_B} = \bar{\theta}$$

Since the VER redirects sales from market  $A$  to market  $B$ , it drives up the costs of producing for market  $B$  (it reduces the marginal product of  $Z$ ), because  $G_{BB} > 0$ . Thus, even if demand for  $B$  is perfectly elastic—that is,  $\bar{P}_B = P_B^*$ —the value of the marginal product of  $Z$  is reduced by the VER. If demand is less than perfectly elastic, that is,  $\bar{P}_B < P_B^*$ , the effect is exacerbated by the drop in price. Hence independent of whether the VER increases or decreases industry revenue, it always reduces the marginal revenue product schedule of its factor inputs. Unless factor supply is entirely inelastic, a falling MRP schedule will cause the industry to reduce both its output and input levels.

The new long-term equilibrium could be represented in figure 1. The transformation curve shrinks inward and is tangential to a price ratio with slope between  $(P_A^*/P_B^*)$  and  $(P_A^V/\bar{P}_B)$  at a point with output  $(\bar{X}_A, X_B'')$  where  $X_B'' > X_B^*$ . Point  $N$  represents one possibility.

A more direct approach to analyzing the long run is directly in terms of the market for the composite factor. Figure 2 illustrates three cases of interest. The VER causes the marginal revenue product curve to fall, say from  $MRP^1$  to  $MRP^2$ . In the very short run, in which factor inputs cannot be changed, the input level remains at  $Z^*$ , but there is a loss of factor rents and therefore welfare to factor owners equal to area  $AEFC$ . Thus there are no output losses but large distortion and resource costs. This, of course, is the implication derived by considering the allocation part of the model alone. In the opposite case, if the footwear industry (in addition to each of its individual firms) faces an infinitely elastic supply of  $Z$ , then the new input level is given by  $\bar{Z}$ ; there are large output losses, but no distortionary resource costs because factors shift to other industries in which they are equally productive. Under these circumstances,  $\bar{\theta} = \theta^*$ , and the shift in the marginal revenue product curve is accommodated by output contraction alone. In another case, the industry faces an upward-sloping supply curve for factors, the final input level is  $\bar{Z}$ , which entails a smaller contraction but imposes welfare losses equal to the area  $AEDB$ . Now

Figure 2. *Three Cases for the Market for the Composite Factor Z Where the VER Causes the MRP Curve to Shift Down*



Note:  $Z^*$  is the short-run case where  $Z$  is fixed at  $Z^*$ .  $\bar{Z}$  is the case where there is an infinitely elastic supply of  $Z$ .  $\bar{Z}$  is the case where there is an upward-sloping supply curve for factors.

$\bar{\theta} < \theta^*$ , and there is an efficiency loss, but it is smaller than that implied in the very short run in which industry factor use is fixed.

In a more complete exposition of the implications of a VER, the number of affected markets would be increased and the two-step approach relaxed. The empirical analysis in section II addresses the more general case in which sales are allocated to one restricted and two unrestricted markets, and we discuss below how the analysis would be modified to increase the number of unrestricted markets. As for the two-step approach, de Melo and Winters (1990) show for the general case of a two-output, one-input technology that spillover to unrestricted markets and output contraction will occur unless there is a very strong positive relation between output destined for one market and the costs of producing for others. (Their findings are also discussed briefly in appendix B.) Because marginal production costs for each market are likely to show only small interdependencies, it is unlikely that the qualitative predictions of the above analysis would differ in a more general setup.

Because we have only two markets, we have been able to establish the contractionary effect of a VER by considering the marginal revenue product in each market directly. With more markets, as in the empirical application below, it is more convenient to use an alternative approach, derived from Neary and Roberts (1980). These authors show that a constrained equilibrium can be expressed as an unconstrained equilibrium at a different set of prices. These



are the virtual prices, mentioned earlier, which are simply the set of prices at which, given the overall level of activity, actual quantities supplied in the constrained equilibrium would be supplied voluntarily. For unconstrained markets, virtual prices are equal to actual prices. Referring back to figure 1, the quantities given by  $R$  would be voluntarily supplied at the set of prices  $(P_A^V, \bar{P}_B)$ , whereas actual prices in the constrained case are represented by  $(\bar{P}_A, \bar{P}_B)$ .

For any unconstrained equilibrium, the value of the marginal product arising from an extra unit of aggregate input  $Z$ , optimally allocated, is a positive function of the set of prices  $(P_1, \dots, P_n)$ ; where  $n - 1$  is the number of unrestricted markets. For a constrained equilibrium, the Neary-Roberts results allow us to calculate the value of the marginal product schedule by evaluating the same function at virtual prices  $(P^V)$ . The effect of a binding VER in market  $A$  is to reduce  $P_A^V$  below its actual price. Because, in unconstrained markets, actual and virtual prices are equal, the reduction in  $P_A^V$  means that at least some prices fall and none rise and that therefore the value of the marginal product falls. Although it is not possible, without knowledge of the factor supply curve, to determine equilibrium values for prices and output, this approach suggests that the VER puts downward pressure on output. This is the procedure used in section II to measure the shift in the marginal revenue product schedule; the equivalent of distance  $EF$  in figure 2.

## II. ESTIMATING THE REDUCTION IN FACTOR DEMAND: KOREAN LEATHER FOOTWEAR

In this section, we present estimates of the effect of the United States's Orderly Marketing Agreement (OMA) on nonrubber footwear on the demand for the factors employed in Korean leather footwear production. We use the simple model described in the previous section: it is assumed that the Korean footwear industry produces an aggregate quantity of footwear using a single composite factor of production, and subsequently allocates this aggregate amount to one of three markets according to a constant elasticity of transformation (CET) allocation function. This simple function allows us to analyze, albeit indirectly, the efficiency implications of the OMA without access to specific data on the allocation of factor inputs to sales in each market. The crucial parameter in our model is the elasticity of transformation, which is a measure of the extent to which production may be shifted between outputs destined for different markets.

In terms of figure 1, it measures responsiveness to changes in the output mix along a given export transformation curve. With this parameter value, it is possible to predict the actual output mix in the OMA period, and the difference between actual and virtual prices during the period. From the latter we can calculate the extent of the shift in the marginal revenue product schedule for the composite factor.

Using quarterly data for the period from the first quarter of 1975 (I) through the fourth quarter of 1986 (IV), we estimate the elasticity of transformation between supplies of leather footwear destined for three markets—the United States, the unconstrained European Community, (which comprises France, the Federal Republic of Germany, Italy, and the Netherlands), and the rest of the world. The United States imposed the OMA on Korean exports of nonrubber footwear between the third quarter of 1977 and the second quarter of 1981, inclusive (although the evidence suggests that the restrictions on Korea ceased to be binding by mid-1980; Aw and Roberts 1986). Hence, the observations corresponding to this period are not included in the estimation period. The unconstrained European Community group, according to Hamilton (1989), imposed no quantitative restrictions on Korean footwear exports over our sample period. Some of the countries in the rest of the world did have import restrictions on footwear, but they may reasonably be treated as unconstrained overall.

Following the model described in section I, individual Korean exporters are assumed to be price takers. They seek to maximize revenues subject to a CET transformation function, which relates the quantities of each type of export footwear to an overall index of output (input); that is,

$$\max_{X_i} \sum_i p_i X_i \quad \text{subject to} \quad \left[ \sum_i a_i X_i^\gamma \right]^{1/\gamma} = \tilde{X}$$

where  $X_i$  is exports to market  $i$  at price  $p_i$ ,  $\tilde{X}$  is the index of aggregate output, and  $\gamma > 1$ .

Writing  $\rho = 1/(\gamma - 1)$  for the elasticity of transformation, standard manipulation allows us to express the share of market  $i$  in total exports as (see Hickman and Lau 1973):

$$(4) \quad s_i = \alpha_i (p_i/p)^\rho; \quad i = 1, 2, 3$$

where  $s_i$  is the share of  $i$  in the volume of exports,  $s_i = X_i / \sum_j X_j$ ,

$$p \equiv \left[ \sum_j \alpha_j p_j^\rho \right]^{1/\rho}$$

is a fixed-weight price index, and  $\alpha_i = a_i^{-\rho}$ .

Although firms are price takers, the exporting industry is not, so the aggregate Korean export price is potentially endogenous to our model. Both this fact and the possibility of there being errors in variables suggest the need for more robust methods of estimation than are possible for nonlinear systems of equations with complex error structures. We decided, therefore, to linearize the model about a base period (see Hickman and Lau 1973). If we set prices to unity in the base period (second quarter of 1984), introduce a time-trend with

value zero in the base period, and add seasonal factors and a lagged dependent variable, we obtain

$$(5) \quad y_{it} = \rho \alpha_i^0 (p_{it} - p_t) + \eta_i t + \sum_k \delta_{ik} D_k + \lambda_1 y_{it-1} + u_{it}$$

where  $y_{it} \equiv s_{it} - \alpha_i^0$  is the deviation of  $i$ 's share from its base value,  $\alpha_i^0$ ,  $p_t \equiv \sum_j \alpha_j^0 p_{jt}$  is a base-weighted price index,  $t$  is a time trend incremented by one per quarter,  $\sum_k \delta_{ik} D_k$  are seasonal effects for quarter  $k$ ,  $k = 1, 3, 4$  where the dummy for the second quarter has been suppressed because the base period is a second quarter,  $\lambda_1$  represents dynamic effects on the share of market  $i$  of its own lagged values, and  $u_{it}$  are stochastic errors.

Because  $y_{it}$  sums to zero over  $i$  in each time period, equation 5 for one of the three markets must be dropped in estimation. We dropped the equation for the unconstrained European Community. We then estimated the remaining equations by a procedure described in appendix A.

The final equation is given in table 1. The estimated elasticity of transformation is perhaps a little low, given the anecdotal evidence that exists on the degree of competition and product substitution-homogeneity in world footwear markets; but it is a fairly robust result. Moreover, two other pieces of evidence suggest that Korean exports to different markets are imperfect substitutes. First, the unit values of Korean exports to different markets differ by up to 50

Table 1. *The Allocation Function for Korean Leather Footwear Exports*

Variable	Estimated coefficient	Standard error
$\rho$	1.311	0.756
$\gamma_R$	-0.0013	0.0009
$\gamma^U$	0.0024	0.0010
$\delta_{R1}$	0.074	0.022
$\delta_{U1}$	-0.076	0.021
$\delta_{R3}$	0.060	0.019
$\delta_{U3}$	-0.063	0.018
$\delta_{R4}$	0.058	0.019
$\delta_{U4}$	-0.060	0.020
$\lambda_1$	0.401	0.102
$\hat{\rho}$	0.137	
$R^2$		
Rest of the world	0.80	
United States	0.88	
Unconstrained European Community	0.75	
Long-run elasticity of transformation <sup>a</sup>	2.19	

Note: The subscript R refers to the rest of the world and the U to the United States;  $\hat{\rho}$  is a first-stage estimate of the autocorrelation parameter.

a. Calculated as  $\rho/(1 - \lambda_1)$ .

Source: de Melo and Winters (1989, appendix).

Table 2. *Estimated Effects of the OMA on Korean Leather Footwear Exports to the United States, 1977–80*

<i>Year and quarter</i>	<i>Actual minus predicted share (1)</i>	<i>Proportionate difference between actual and virtual price (2)</i>	<i>Change in aggregate price index (3)</i>
1977,3	-0.176	-0.121	-0.095
1977,4	-0.024	-0.017	-0.013
1978,1	-0.076	-0.050	-0.039
1978,2	-0.159	-0.103	-0.081
1978,3	-0.098	-0.056	-0.044
1978,4	-0.093	-0.051	-0.040
1979,1	-0.208	-0.096	-0.076
1979,2	-0.188	-0.081	-0.063
1979,3	-0.284	-0.110	-0.087
1979,4	-0.159	-0.065	-0.051
1980,1	-0.052	-0.023	-0.018
1980,2	-0.092	-0.040	-0.031

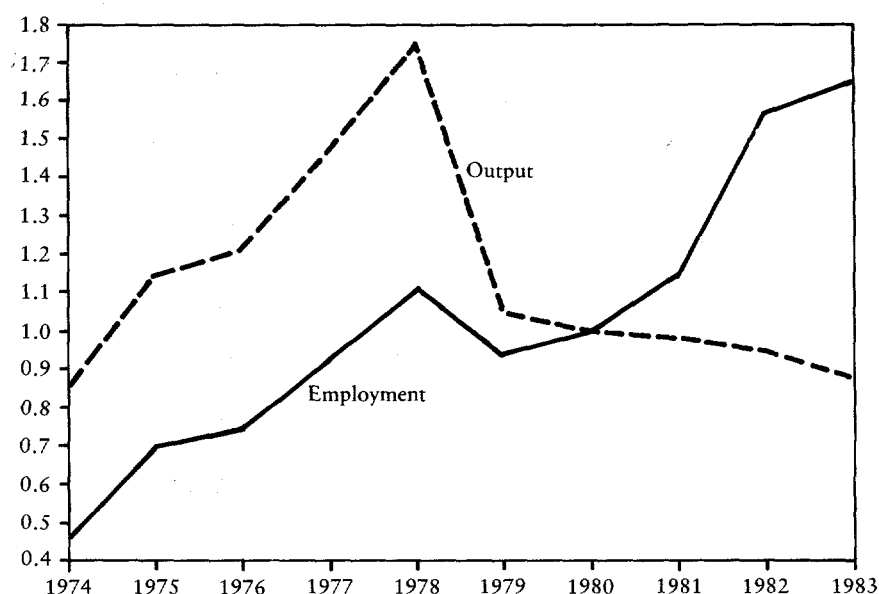
Source: table 1 and authors' calculations.

percent, which suggests that there may indeed be genuine product heterogeneity. Second, the estimates in table 1 display dramatically different seasonal patterns—with the allocation of shares between the United States and the rest of the world switching by over 10 percentage points with the season.

Table 2 explores the effects of the OMA on Korean exports to the United States more closely. On the basis of our estimates, we can predict the share of exports to the United States in the OMA period if quantities had been unconstrained at the actual price. Column 1 reports the difference between the actual and predicted shares during the OMA period. It is consistently negative, which suggests that the OMA was binding, although it shows signs of weakening during 1980. Column 2 approximates the proportionate difference between the virtual and actual prices of exports to the United States. Because the actual U.S. share falls short of that predicted by the export allocation model, the virtual price for the United States is below the actual price by as much as 12 percent (in third quarter of 1977). Thus the OMA may be seen to have had an effect equivalent to reducing the price of exports to the United States by 5–12 percent below actual levels with no compensating price rises in other markets. This makes it clear that the OMA put pressure on the Korean footwear industry to contract.

The extent of the contractionary pressure can be calculated as the difference in the aggregate price index evaluated at actual and virtual prices. This calculation, reported in column 3 of table 2, is a linear approximation to the change in the marginal return to the aggregate factor in the leather footwear sector. It shows that the marginal revenue product of the factors of production in the

Figure 3. *Index of Employment and Output in Footwear Relative to All Manufacturing (1980 = 1)*



leather footwear industry declined by as much as 9 percent because of the OMA.<sup>3</sup>

The econometric estimates strongly suggest that the Korean footwear industry would have contracted during the period of the OMA. This prediction is supported by time series data on output, employment, and wages of the Korean footwear sector. These data are illustrated in figure 3, which reports footwear output and employment relative to the corresponding series for the entire manufacturing sector: although Korean industry generally contracted over this period (see appendix table A-1), the footwear sector suffered more than average. Output and employment in the footwear industry peaked in 1978, one year after the signing of the OMA agreement. This peak is later than predicted by our model, but it is not out of line with the detailed account of the OMA given by Yoffie (1983). He remarks that Korean producers went to considerable lengths to negotiate the OMA in a fashion that allowed extended periods of adjustment. Thus it is quite conceivable that output and employment remained high into 1978.

3. Comparisons with free trade rather than actual prices would reduce these estimates somewhat. In the absence of an estimated elasticity of demand, however, the former are not calculable, but the higher the elasticity of demand the smaller the difference. In our simulation results below, we use free trade prices.

One of the causes of the Korean slump was rising real wages over the period 1977–79, which might have harmed labor-intensive industries such as footwear. In fact, wages in footwear fell during 1978 relative to those in other labor-intensive sectors such as textiles, apparel, and leather products. Thus although it cannot be entirely ruled out that the time series on footwear reflect only economywide phenomena, there is some evidence of particular hardship in the footwear sector. Certainly we find nothing to refute our prediction that the OMA caused a contraction of Korea's footwear sector.

### III. ILLUSTRATIVE WELFARE CALCULATIONS

The results above confirm our hypothesis that a VER leads to output contraction and has adverse effects on efficiency if the factors employed in the industry are not available to it in perfectly elastic supply. However, as discussed in section I, a VER also results in revenue effects which may either reinforce or counteract the efficiency costs. (It was demonstrated in section I that the latter, in the long run, lead the industry to contract and to reduce factor incomes.) The combined long-run effect is captured in the calculation of the welfare effect, which is estimated by simulation techniques in this section. Welfare effects are calculated by adding the gains in or losses of profits to firms and the loss of income to factors.

The simulation model is used to provide rough orders of magnitude of the potential welfare effects of a VER, using the U.S. OMA on Korean exports of leather footwear as a reference case. The calibrated simulations are based generally on the model presented in section I, with constant foreign price elasticities of demand; a CET function describing sales allocation; and a constant elasticity of factor supply. (Further details are given in appendix B.)

For the reference-case calculations, we use our estimate of the elasticity of transformation from section II to measure the ease with which exporters may divert sales from restricted to unrestricted markets and complement it with rough estimates of factor supply elasticities and price elasticities of export demand. Our estimates of the price elasticity of export demand are consistent with the range of 0.5–1.0 reported by Pearson (1983, p. 78) and Goldstein and Khan (1985).

Welfare is measured by the sum of profits and factor incomes, and the change in welfare is expressed as a proportion of variable factor ( $Z$ ) income before the VER. The change in factor demand from the restricted industry affects the wages throughout the markets in which the factors are traded and the contraction of the restricted industry drives down factor rewards both for itself and for any other industry using the same factors. Hence a given wage reduction has a larger impact on welfare, the larger the stock of factors affected. This effect is represented crudely in the welfare calculations by  $L$ , the size of the total factor stock affected relative to the initial size of the affected industry,  $Z$ . A value of  $L = 1$  implies that initially only the VER-affected industry employs the factor

concerned; a value of 5 implies that the VER industry originally employed 20 percent of the relevant factor stock. Because  $L$  will vary depending on the industry under consideration, we give calculations for cases where the market for the variable factor  $Z$  is 1, 5, or 10 times the initial allocation to the industry under the VER.

Illustrative calculations for a range of elasticities are given in table 3. For all calculations, it is assumed that there is a 10 percent reduction in the volume of sales to the restricted market, where the initial share of exports to the restricted market is 42 percent of total exports (a figure corresponding to the leather footwear case). Before examining the results for the different elasticities shown as the five cases of the table, in which several elasticities are varied simultaneously, we describe briefly the effects of varying elasticities one by one and compare the results with those in case 1, where all elasticities are unity.

In the case of unitary export demand elasticities, there are no sales revenue effects, so it is easy to isolate the effects of varying supply elasticities. The more difficult it is to reallocate the existing volume of production, the higher the

Table 3. *Illustrative Welfare Calculations*

Item	Case				
	1	2	3	4	5
	Value of elasticity				
Type of elasticity					
Price elasticity of restricted demand, $\epsilon_A$	1.0	0.3	0.5	1.0	2.0
Price elasticity of unrestricted demand, $\epsilon_B$	1.0	0.6	1.0	2.0	4.0
Elasticity of transformation, $\rho$	1.0	0.5	1.5	1.5	3.0
Elasticity of factor supply, $\epsilon_S$	1.0	0.5	2.0	2.0	3.0
	Result of simulation				
Variable					
Output <sup>b</sup>	-5.0	-3.9	-4.3	-4.5	-4.1
Sales revenue <sup>b</sup>	0.0	11.6	4.6	0.0	-2.1
Factor wage <sup>b</sup>	-4.0	-7.7	-2.2	-2.3	-1.4
Welfare <sup>c</sup>					
1	6.2	19.7	10.2	5.5	2.7
5	-0.5	6.9	6.5	1.7	0.4
10	-8.9	-9.1	1.9	-3.0	-2.5

Note: Notation is given in appendix B, equation, B-2. Unrestricted equilibrium:  $X_A = 100$ ;  $X_B = 140$ ;  $P_i = 1.00$ ;  $Z = 100$ .

a. Size of market for  $Z$  in relation to initial allocation of  $Z$  in industry subject to VER.

b. Percentage change.

c. Change in income expressed as a share of initial variable factor income (see appendix B, equation B-13). These changes are shown for three values of the size of the total factor stock affected relative to the initial size of the affected industry.

Source: table 1 and authors' calculations.

efficiency cost of a given VER because the adjustment comes from output contraction rather than from sales reallocation. Likewise, as explained in section I, the higher the elasticity of factor supply, the lower the efficiency costs of a VER. Indeed, a similar variation (around unity) of the elasticity of factor supply has more of an effect on efficiency than will an equal variation of the elasticity of transformation.

Cases 2 through 5 give estimates of the welfare effects of a VER for low, medium, and high sets of elasticities. The results in case 4 may be viewed as best guess calculations. In the case of a VER, there is a net loss if the market for Z is large. But if the market for Z is small (relative to the initial allocation of Z to the industry), there is a net gain from the VER despite the negative efficiency effects because of their relatively smaller weight in the welfare calculation. The same is true for the case where all the elasticities are low (case 2). The larger efficiency costs are offset by the larger revenue gains. It is also noteworthy that the simulated decreases in the marginal revenue product of Z (represented by the factor wage row of table 3) are similar in magnitude to the range reported from the econometric estimates in column 3 of table 2. Finally, in case 5, with higher demand elasticities, the revenue effect becomes negative, which implies larger welfare losses. Thus, if demand elasticities are not too low and supply elasticities are not too high, a VER is likely to lead to a welfare loss.<sup>4</sup>

Although the net effects of the VER are fairly small in table 3, the gross effects are significant. The VER increases profits for those with the right to export to the restricted markets but harms all other agents. In particular, labor is likely to lose from industrial-country protection, an ironic result in light of the fact that protection is often advocated as a means of protecting workers. If so, protection should be seen as a means of protecting rich industrial country workers at the expense of workers in poor developing countries.

#### IV. CONCLUSIONS

This article has presented a simple model to analyze the revenue and efficiency effects of a VER at the industry level. Motivated by the evidence that developing countries often have limited success in switching sales toward unrestricted markets, we have analyzed the impact on the exporting industry. In order to do this, we have separated revenue effects arising from sales reallocation toward unrestricted markets from efficiency effects arising from output contraction.

The analytical discussion of the effects of a VER was then corroborated with an application to the U.S. OMA agreement with Korean exporters of leather

4. The elasticity of factor supply ( $\epsilon_s$ ) is not independent of the relative size of the industry in the factor market ( $L$ ). For example, for an industry like footwear,  $\epsilon_s$  is likely to be in the range of 2–4 and  $L$  perhaps 10 or more, whereas in textiles, the corresponding pair would be  $\epsilon_s$  in the range of 0.5–2.0 and  $L$  around 5.



footwear. The econometric estimates indicate both a limited ability to switch sales toward unrestricted markets and a sharp fall in the marginal revenue product of factors employed in the Korean leather footwear industry during the period where the OMA was in effect. Combined with extraneous estimates of export demand and factor supply elasticities, illustrative welfare calculations suggest that the OMA may well have resulted in a welfare loss to exporting countries, especially if demand elasticities are relatively elastic and supply responses relatively inelastic.

#### APPENDIX A

This appendix presents a detailed description of the econometric model of export allocation introduced in section II and an account of its estimation. We assume that exporters are price takers and that they seek to maximize their revenues subject to a CET transformation function relating the quantities of each type of footwear export to an overall index of output (input). Their objective is

$$(A-1) \quad \max_{X_i} \sum_i p_i X_i \quad \text{subject to} \quad \left[ \sum_i a_i X_i^\gamma \right]^{1/\gamma} = \bar{X}$$

where  $X_i$  is exports to market  $i$ , at price  $p_i$ ,  $\bar{X}$  is the index of aggregate output, and  $\gamma > 1$ .

Standard manipulations (see Armington 1969) produce supply functions for the individual markets,

$$(A-2) \quad X_i = a_i^{-\rho} (p_i/p^*)^\rho \bar{X}$$

where  $p^*$  is the dual CET price index of  $\bar{X}$  given by:

$$(A-3) \quad p^* = \left[ \sum_i a_i p_i^{(1+\rho)} \right]^{1/(1+\rho)}$$

and

$$\rho = \left[ \frac{1}{\gamma - 1} \right]$$

is the (negative of the) elasticity of transformation between exports for any pair of markets;  $\rho > 0$ .

Further manipulation (see Hickman and Lau 1973) transforms equation A-2 into the more convenient form:

$$X_i = \alpha_i p_i^\rho \left[ \sum_j \alpha_j p_j^\rho \right]^{-1} \bar{X}$$

or

$$(A-4) \quad s_i = \alpha_i (p_i/p)^\rho + u_i$$

where  $X \equiv \sum_j X_j$  is a simple aggregation of exports,  $s_i$  is the share of  $i$  in the volume of exports,

$$p \equiv \left[ \sum_j \alpha_j p_j^\rho \right]^{1/\rho}$$

is a fixed-weight price index,  $\alpha_i = a_i^{-\rho}$ , and  $u_i$  is a stochastic component added at this stage for estimation purposes.

To facilitate the treatment of simultaneity and errors in variables, equation A-4 is linearized about a base period. We used the second quarter of 1984 as the base because it lay well outside the period of possible rationing, and yet was relatively central to our sample of unrationed observations. Subsequent tests suggested that the choice of base period affects the results slightly, but not sufficiently to disturb the qualitative conclusions in the text. If we set prices to unity in the base period, introduce a time trend with value zero in the base, and add seasonal factors and dynamics, the linearization gives

$$(A-5) \quad y_{it} = \rho \alpha_i^0 (p_{it} - p_t) + \eta_i t + \sum_k \delta_{ik} D_k + \lambda_1 y_{it-1} + \lambda_4 y_{it-4} + u_{it}$$

where  $y_{it} \equiv s_{it} - \alpha_i^0$  is the deviation of  $i$ 's share from its base value,  $\alpha_i^0$ ,  $p_t$ ,  $\alpha_i^0 \equiv \sum_j \alpha_j^0 p_{jt}$  is a base-weighted price index,  $t$  is a time trend incremented by one per quarter,  $\sum_k \delta_{ik} D_k$  are seasonal effects for quarter  $k$ ,  $k = 1, 3, 4$  where the dummy for quarter two has been suppressed because the base period is a second quarter, and  $\lambda_1$ ,  $\lambda_4$  represent dynamic effects on the share of market  $i$ , felt through lags of itself.

Adding up requires that  $\sum_j \alpha_j = 1$  and that  $\sum_j \delta_{jk} = \sum_j \gamma_j = \sum_j u_{jt} = 0$  for all  $k$  and  $t$ . The first condition is satisfied automatically; the latter, by dropping the equation for the unconstrained European Community. Usually with this procedure, the final estimates are invariant with respect to the equation dropped, but because of the methods required by the errors in the variables, that is the use of instrumental variables, this is not so. In practice, however, the choice made very little difference.

Adding up also requires that, unless the errors are characterized by full vector autoregression, the dynamic structure implied by the lags  $\lambda_1$  and  $\lambda_4$  must be common to all commodities. The lag  $\lambda$  therefore appears in both equations as a cross-equation restriction. The use of lagged dependent variables may be justified on several grounds—for example, partial adjustment of price expectations, as in Hickman and Lau (1973), or habit formation. For systems of sum-constrained equations, it represents by far the most convenient approach to dynamic generalization. The choice of lags 1 and 4 to capture the dynamics was made a priori on the basis of previous experience with quarterly data sets.

Equation A-5 may be stacked over  $i$  and written in matrix form:

$$(A-6) \quad \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} \alpha_1^0(p_1-p) & t & 0 & D_1 & 0 & D_3 & 0 & D_4 & 0 & Ly_1 & L^4y_1 \\ \alpha_2^0(p_2-p) & 0 & t & 0 & D_1 & 0 & D_3 & 0 & D_4 & Ly_2 & L^4y_2 \end{bmatrix} \begin{bmatrix} \rho \\ \eta_1 \\ \eta_2 \\ \delta_{11} \\ \delta_{21} \\ \delta_{13} \\ \delta_{23} \\ \delta_{14} \\ \delta_{24} \\ \lambda_1 \\ \lambda_4 \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

where  $L$  is the lag operator and all the roman letters denote  $(n \times l)$  vectors, where  $n$  is the number of observations.

Ignoring the errors in variables, equation A-6 may be simply estimated allowing for autocorrelation and cross-equation correlations. Following Parks (1967), we first estimate A-5 for each commodity separately, and calculate a single first-order autocorrelation coefficient. (The serial correlation adjustment factor must be common to all equations if the system is to add up). Transforming the data appropriately, we then reestimate by commodity to calculate  $E(\tilde{u}_i \tilde{u}_{ji})$ , where the  $\tilde{u}_i$  are the errors from the transformed equations. Finally, using these variances and covariances, we transform the data again to estimate equation A-6 by generalized least squares.

To allow for the simultaneity and the errors in variables, we use instrumental variable estimation. The technique presumes that the instrumental variables are correlated with the true values of the variables in equation A-5 but not their errors of observation. If this is true, our estimates are consistent and asymptotically efficient. Instruments were drawn from both the importing countries (industrial production, the wholesale price index for manufactures, and the exchange rate vis-à-vis the dollar) in order to reflect demand factors, and from Korea (the per unit value of manufactured exports, the index of industrial production, and the dollar exchange rate) to reflect broad supply-side phenomena. Whenever  $L_y$  and  $L_y^4$  are included in the equation, the instrumental variables are also included in lagged form. Finally, the genuinely exogenous variables in A-6—that is,  $D_i$  and  $t$ —are also included in the set of instruments.

The estimation method is based on Aigner and others (1984). We assume that there exists a true relation equivalent to equation A-6 but without errors in variables, and which may be written as:

$$(A-7) \quad y = \xi\beta + u \quad ;$$

where  $\xi$  represents the true value of  $X$  and  $y$  and  $u$  have their usual definitions. The relation between the true  $\xi$  and the observed  $X$  independent data is

$$(A-8) \quad X = \xi + V$$

There also exists a set of relations between the  $k$  true independent variables and the  $l$  indicator (instrumental) variables ( $Z$ ).

$$(A-9) \quad Z = \xi\Gamma' + \Delta.$$

The error terms  $V$  and  $\Delta$  are assumed to be independently normally distributed with zero means and also to be independent of  $\xi$ . The covariances of the rows of  $V$  and  $\Delta$  ( $v_i$  and  $\delta_i$ ) are given by  $\Omega$  and  $\theta$  respectively and the variance of  $u$  by  $\sigma^2$ . The true independent variables are assumed to have an expected scaled cross-product matrix,  $K = E m^{-1} \xi' \xi$ , where  $m = 2n$  is the number of rows in the matrixes  $y$ ,  $X$ ,  $Z$ ,  $\xi$ ,  $V$ , and  $\Delta$ . Following Aigner and others, we can write the various covariance matrices  $\Sigma_{ij} = E m^{-1} i' j'$ , for  $i, j = X, y, Z$  as

$$(A-10a) \quad \Sigma_{yy} = \sigma^2 + \beta' K \beta$$

$$(A-10b) \quad \Sigma_{xy} = K \beta$$

$$(A-10c) \quad \Sigma_{zy} = \Gamma K \beta$$

$$(A-10d) \quad \Sigma_{zz} = K + \Omega$$

$$(A-10e) \quad \Sigma_{zx} = \Gamma K$$

$$(A-10f) \quad \Sigma_{zz} = \Gamma K \Gamma' + \theta$$

Equations (A-10c) and (A-10e) yield

$$\Sigma_{zy} = \Sigma_{zx} \beta$$

from which, multiplying both sides by  $\Sigma'_{zx} \Sigma_{zz}^{-1}$  and substituting sample values  $S_{ij}$  for population values  $\Sigma_{ij}$  we obtain

$$(A-11) \quad \begin{aligned} \hat{\beta} &= (S'_{zx} S_{zz}^{-1} S_{zx})^{-1} S'_{zx} S_{zz}^{-1} S_{zy} \\ &= [X' Z (Z' Z)^{-1} X' Z] (Z' Z)^{-1} Z' y. \end{aligned}$$

$\hat{\beta}$  is multivariately normally distributed with asymptotic variance

$$(A-12) \quad \text{var}(\hat{\beta}) = (\sigma^2 + \beta' \Omega \beta) (S'_{zx} S_{zz}^{-1} S_{zx})^{-1}$$

which is the minimum variance bound that can be derived by linear methods. We approximate A-12 below by substituting  $\hat{\beta}$  for  $\beta$  and using A-10 to express the first bracket in terms of observables.

System A-10 presumes that the errors are independently and identically distributed, but in our case we need to allow for the presence of autocorrelation and the fact that  $E(u_1 u_2) \neq 0$  where  $u_1$  and  $u_2$  are subvectors of  $u$  referring to the first and second equations. In fact, however, these modifications make virtually no difference to the estimator. Taking the latter first, partitioning all variables in A-7 to A-9 conformably with  $u_1$  and  $u_2$ , versions of A-10 may be

derived for all combinations of  $y_i$ ,  $X_i$  and  $Z_i$ ,  $i = 1, 2$ . If the only change in assumption is that  $E(u_i u_j) = \sigma_{ij}$ ,  $i \neq j$ , only A-10a is changed; it becomes

$$(A-10a') \quad \Sigma_{y_i y_j} = \sigma_{ij}^2 + \beta' K \beta$$

In all other equations, the partitioned covariances are the same as the unpartitioned ones in A-10. This means that the same instrumental estimation method may be applied to a set of first-stage estimators to derive the  $\hat{\sigma}_{ij}$ , which are then used to transform all the observable data into the form assumed in the main stage just described. Provided that the estimates of  $\sigma_{ij}$  are consistent, the asymptotic properties of the final estimates are unchanged. A similar approach is taken to the autocorrelation.

The variance estimate (equation A-12) may be used to conduct statistical inference on the coefficients. The validity of a set of  $q$  linear constraints,  $Q\beta = r$ , may be explored by means of the test statistic

$$(Q\hat{\beta} - r)' [Q \text{Var}(\hat{\beta}) Q']^{-1} (Q\hat{\beta} - r)$$

which is distributed  $X_q^2$  under the null hypothesis (see Amemiya 1985). This test suggested that it was acceptable to set  $\lambda_4 = 0$  in the final equation.

(The data were collected and prepared by Taeho Bark and Paul Brenton from Korean Customs data publications. They are fully described in the appendix of de Melo and Winters 1989. In terms of the final classifications in table 2 of that source, leather footwear is defined here as headings 6402.1000–6402.4900.)

Appendix Table A-1. *The Korean Footwear Sector, 1974–83*

Year	Footwear			Footwear as a percentage of total manufacturing		
	Employment <sup>a</sup>	Output <sup>b</sup>	Wages <sup>c</sup>	Employment	Output <sup>d</sup>	Wages
1974	6,600	33	303	0.518	85.3	85.3
1975	11,000	53	364	0.788	114.5	77.9
1976	14,200	74	493	0.84	121.3	82.6
1977	19,800	108	657	1.046	147.1	85.1
1978	26,000	159	846	1.249	174.9	79.3
1979	22,000	107	1,136	1.055	105.0	81.1
1980	22,700	100	1,366	1.127	100.0	79.2
1981	26,000	111	1,538	1.293	97.9	74.8
1982	36,500	113	1,809	1.77	94.6	78.4
1983	40,500	122	2,025	1.86	87.8	80.2

a. Person-years.

b. Index: 1980 = 100.

c. In thousands of won per year.

d. Ratio of index numbers: 1980 = 100.

Source: U.N. Industrial Development Organization data.

## APPENDIX B

*General Model and Welfare Calculations*

*General model.* Consider the general case of firms in perfect competition in which the allocation and input decisions are made jointly.<sup>5</sup> In this case, weak separability is not imposed on the allocation and production decisions. Technology is represented by a one-input, two-output production function. Let variable factor requirements,  $Z$ , allocated to the restricted ( $X_A$ ) and unrestricted ( $X_B$ ) markets be given by:

$$(B-1) \quad Z = G(X_A, X_B)$$

where  $Z$  is the quantity used of the composite factor,  $G_i$  is  $\partial Z / \partial X_i > 0$ , and  $G$  is homothetic and homogeneous of degree  $r < 1$ . Under the assumption of profit maximization, de Melo and Winters (1990) show that the imposition of a VER on sales to  $A$  ( $\bar{X}_A < X_A^*$ ), leads to the following expressions for output (B-2) and for national welfare (B-3).

$$(B-2) \quad \frac{1}{G_A} \frac{dZ}{d\bar{X}_A} = \frac{\left[ \frac{G_B}{X_B \epsilon_B} - G_{BB} + \frac{G_B}{G_A} G_{BA} \right]}{\left[ \frac{G_B}{X_B \epsilon_B} - G_{BB} - \frac{G_B^2}{Z \epsilon_Z} \right]} = H$$

$$(B-3) \quad \frac{dU}{d\bar{X}_A} = \left[ \left[ \frac{1}{\epsilon_A} - \frac{1}{\epsilon_B} \right] + \left[ \frac{1}{\epsilon_B} - \frac{1}{\epsilon_N} \right] H \right] G_A$$

where  $\epsilon_A, \epsilon_B, \epsilon_N < 0$  are respectively the elasticities of demand for  $A$ ,  $B$ , and the variable factor  $Z$  with respect to the wage in other sectors using  $Z$ ,  $\epsilon_Z > 0$  is the elasticity of supply of  $Z$ . From B-2, it is clear that a VER in  $A$  will most likely lead the industry to contract if one assumes increasing marginal costs, that is,  $G_{ii} > 0$ , and if one recognizes the constraints imposed by the second-order conditions for profit maximization. Only very strong (and implausible) interactions between  $A$  and  $B$  leading to a large positive value for  $G_{AB}$  would lead the industry to expand. Hence, a VER is likely to lead the industry to contract.

From B-3, the change in national welfare defined as the sum of industry profits and factor payments is determined by an allocation component which measures whether switching sales from  $A$  to  $B$  raises revenue, and a size component which measures whether switching factors across sectors is beneficial.

*Welfare calculations.* The welfare calculations in section III come from a numerical application of the model presented in section I, with constant elasticity of demand curves (equations B-4 and B-5); a CET function to allocate sales between the restricted and unrestricted markets  $A$  and  $B$  (equation B-6); and a

5. This appendix draws on de Melo and Winters (1990).

constant elasticity of supply function for the factor,  $Z$  (equation B-11). An unrestricted equilibrium is described by the following set of equations:

$$(B-4) \quad X_A = A_A P_A^{-\epsilon_A} \quad \epsilon_A > 0$$

$$(B-5) \quad X_B = \bar{A}_B P_B^{-\epsilon_B} \quad \epsilon_B > 0$$

$$(B-6) \quad \tilde{X} = \bar{A}_C (\alpha_A X_A^\gamma + \alpha_B X_B^\gamma)^{1/\gamma} \quad \rho = 1/\gamma - 1; \gamma > 0$$

$$(B-7) \quad P_A = \theta^* \bar{A}_C^{(\rho+1)/\rho} \alpha_A (X_A / \tilde{X})^{1/\rho}$$

$$(B-8) \quad P_B = \theta^* \bar{A}_C^{(\rho+1)/\rho} \alpha_B (X_B / \tilde{X})^{1/\rho}$$

$$(B-9) \quad \tilde{X} = X^S$$

$$(B-10) \quad X^S = \bar{A}_S Z \epsilon_Z$$

$$(B-11) \quad Z = \bar{A}_Z P_Z^{\epsilon_Z}; \epsilon_Z > 0$$

$$(B-12) \quad P_Z = \bar{A}_S \theta^*$$

where  $\bar{A}_i$ , ( $i \in A, B, C, Z, S$ ) are normalizing constants determined by calibration, that is, constants calculated so that the set of equations describing the model is satisfied for the initial levels of prices and quantities. In the free-trade equilibrium, industry profits,  $\pi$ , are zero as sales revenue equals payments to  $Z$ ,  $P_Z Z$ .

With the VER,  $X_A$  is fixed at  $\bar{X}_A < X_A$  and the first-order condition for the allocation to the restricted market (B-7) is dropped. As explained in section I, as a result of the VER,  $\bar{\theta} > \theta^*$  (unless  $\epsilon_Z = \infty$ ).

The welfare measure is:

$$(B-13) \quad \Delta W = W_1 - W^* = (\Delta \pi + \Delta P_Z L) / P_Z Z$$

where  $L$  is a scalar indicating the size of the industry in the market for  $Z$ .

The calculations in section III are obtained by solving the model represented by equations B-4 to B-12 for an unrestricted equilibrium and for a restricted equilibrium with  $\bar{X}_A = 0.9 X_A^*$ . When elasticities are varied, the  $\bar{A}_i$  parameters are recalibrated so as to start from the same initial unrestricted values for prices and quantities.

## REFERENCES

- Aigner, D. J., C. Hsia, Arie Kapteyn, and Tom Wansbeek. 1984. "Latent Variable Models in Econometrics." In Zvi Griliches and M. D. Intriligator, eds., *Handbook of Econometrics*, vol. 2. Amsterdam: North-Holland.
- Amemiya, Takeshi 1985. *Advanced Econometrics*. Oxford: Blackwell.

- Armington, P. S. 1969. "A Theory of Demand for Products Distinguished by Place of Production." *International Monetary Fund Staff Papers* 16: 159-76.
- Aw, B. Y., and M. S. Roberts. 1986. "Measuring Quality Change in Quota-Constrained Import Markets." *Journal of International Economics* 21: 45-60.
- Baldwin, Robert 1982. "The Inefficacy of Trade Policy." Essays in International Finance no. 150. Princeton, N.J.: Princeton University. Processed.
- Bark, Taeho, and Jaime de Melo. 1988. "Export Quota Allocations, Export Earnings, and Market Diversification." *World Bank Economic Review* 2, no. 3 (September): 341-48.
- Bhagwati, Jagdish. 1986. "VERS, Quid Pro Quo DFIs, and VIEs: Political Economy Theoretic Analyses." *International Economic Journal* 1: 1-14.
- Dinopoulos, Elias, and Mordechaie Kreinin. 1988. "Effects of the U.S.-Japan Auto VER on European Prices and U.S. Welfare." *Review of Economics and Statistics* 70: 484-91.
- Feenstra, Robert 1985. "Automobile Prices and Protection: The U.S.-Japan Trade Restraint." *Journal of Policy Modelling* 7: 49-68.
- Goldstein, Morris, and Mohsin Khan. 1985. "Income and Price Effects in Foreign Trade." In Ronald Jones and Peter Kenen, eds., *Handbook of International Economics*, vol. 2. Amsterdam: North-Holland.
- Hamilton, Carl 1989. "The Political Economy of Transient 'New' Protectionism." *Weltwirtschaftliches Archiv* 125: 522-46.
- Hickman, B. G., and L. J. Lau. 1973. "Elasticities of Substitution and Export Demands in a World Trade Model." *European Economic Review* 4: 347-80.
- Hufbauer, G. C., D. T. Berliner, and K. A. Elliot. 1986. *Trade Protection in the United States: 31 Case Studies*. Washington, D.C.: Institute for International Economics.
- Melo, Jaime de, and L. Alan Winters. 1989. "Price and Quality Effects of VERS Revisited: Case Study of Korean Footwear Exports." Policy, Planning, and Research Discussion Paper 216, World Bank. Washington, D.C. Processed.
- . 1990. "Do Exporters Gain from VERS?" Discussion Paper 383. London Center for Economic Policy Research. London, England. Processed.
- Neary, Peter, and K. Roberts. 1980. "The Theory of Household Behavior Under Rationing." *European Economic Review* 13: 25-42.
- Nogués, Julio, Andrzej Olechowski, and L. Alan Winters. 1986. "The Extent of Non-tariff Barriers to Industrial Countries' Imports." *World Bank Economic Review* 1, no. 1 (September): 181-99.
- Parks, R. W. 1967. "Efficient Estimation of a System of Regression Equations when Disturbances Are Both Serially and Contemporaneously Correlated." *Journal of the American Statistical Association* 62: 500-09.
- Pearson, C. 1983. *Emergency Protection in the Footwear Industry*. London: Trade Policy Research Center.
- Tarr, David G. 1987. "Effects of Restraining Steel Exports from the Republic of Korea and Other Countries to the United States and the European Economic Community." *World Bank Economic Review* 1, no. 3 (May): 397-418.
- Trela, Irene, and John Whalley. 1988. *Do Developing Countries Lose from the MFA?* National Bureau of Economic Research Working Paper 2618. Cambridge, Mass.



- Winters, L. A., and P. A. Brenton. 1988. "Non-Tariff Barriers to International Trade: UK Restrictions on Imports of Leather Footwear from Eastern Europe." University College of North Wales, Bangor. Processed.
- Yoffie, David 1983. *Power and Protectionism*. New York: Columbia University Press.